Applications of nanocolumnar coatings with light localization properties

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Substrates and/or surfaces with the ability of providing local light confinement show an extended range of applications, from surface-enhanced spectroscopies to solar cells or fluorescence imaging. These substrates are usually based on the presence of plasmonic nanostructures, and are obtained by means of lithographic or self-assembly methods. However, these methods are often complex or expensive. The use of fabrication techniques that are simple, low cost and easily adaptable to large-scale fabrication can therefore help to further extend the use of this kind of substrates. In the last years, we have fabricated metallic coatings with nanocolumnar morphology by means of glancing angle deposition (GLAD) with magnetron sputtering [1]. Depending on the deposition parameters (such as gas pressure, tilt angle, substrate rotation, etc.), the nanocolumns structure can be controlled, giving rise to different properties.
Here, we will present three different kinds of nanocolumnar coatings and their optical properties. First, coatings consisting of vertical gold nanocolumns, obtained at very high tilt deposition angle, will be shown. These coatings give rise to black metal behavior in the visible range [2], associated to multiple scattering processes. Next, coatings based on short tilted gold nanocolumns we will be described. The near-field characterization of these surfaces demonstrates the presence of hot spots in a broadband range. This results in the presence of broad-band surface-enhanced Raman signal, pointing out the interest of these coatings as SERS substrates [3]. Finally, TiO_2 nanocolumns integrated in perovskite solar cells will be analyzed. In this case, the nanocolumns are obtained by first depositing Ti nanocolumns and then oxidizing them through a thermal treatment. The TiO_2 layer acts as the electron transport layer of the cell, and compared with planar layers, the TiO_2 nanocolumns can significantly enhance the power conversion efficiency of the perovskite solar cells by 7% and prolong their shelf life. By analyzing the optical properties, solar cells characteristics, as well as transport/recombination properties by impedance spectroscopy, we observed light-trapping and reduced carrier recombination in solar cells associated with the use of the TiO_2 nanocolumnar layer [4].

References

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